Reprinted from *1998 Columbia Basin Agricultural Research Annual Report. Spec. Rpt. 989,* pp. 53-60, 1998
Oregon State University in cooperation with USDA-Agricultural Research Service, Pendleton, OR

STREAM MORPHOLOGICAL DESCRIPTION OF THE UMATILLA RIVER

John D. Williams, Caty F. Clifton, and Ron W. Rickman

Introduction

Congress enacted the Federal Clean Water Act in 1972 and charged the U.S. Environmental Protection Agency (EPA) with the responsibility for protecting and cleaning the Nation's surface water resources. Fourteen years later, the Northwest Environmental Defense Center and other interested parties filed suit (NEDC et al., 1986) against EPA, alleging that EPA was not fulfilling this responsibility as mandated by the Federal Clean Water Act. Because of this litigation, EPA consented that it had obligations under section 303d of the Clean Water Act for the water quality of Oregon waterways if the State of Oregon did not accept that responsibility. NEDC et al. filed a second suit (National Environmental Defense Center et al. v. EPA, 1994) claiming that Oregon had not fulfilled the requirements in section 303d. Because of this shortcoming, the suit asked that EPA be compelled to fulfill the responsibility. In response, EPA consented to act by May of 1996 on any list submitted by the State of Oregon. In September 1996, Northwest Environmental Advocates et al. filed a third suit against the director of EPA and the EPA (NEA et al. v. Browner et al., 1996) challenging EPA's approval of Oregon's 1994–1996 list of streams exceeding section 303d standards. The suit also asked that the EPA establish a schedule for development of total maximum daily loads (TMDL) to meet 303d standards (EPA 1998). TMDL is the total measured amount of a pollutant or its measure that a stream is allowed to have in a day (24 hr). Examples of pollutants or their measures are temperature, pesticides, nutrients, pH, dissolved oxygen, or eroded soil. TMDL has also come to be known as the process by which water–quality limits are set. In agreements worked out since the filing of the lawsuits, EPA, the State of Oregon, local governments, and landowners located within watershed boundaries have been working cooperatively to establish TMDL limits. These limits will guide efforts of governments and private landowners to attain and maintain water quality standards. The purpose of this paper is to report on efforts of the USDA-Agricultural Research Service (ARS) and USDA-Forest Service (USFS) cooperating on the development of the Umatilla Watershed TMDL.

Efforts to maintain or improve water quality can only be accomplished through integrated watershed management efforts. An important, but largely unrecognized, part of this effort is the quantification of watershed attributes that influence water quality. These attributes are the structural components of a watershed and include, but are not limited to, land use, plant communities, wildlife, geology, roads, buildings, soils, and stream shape (morphology). The structure of a watershed controls how the quantity, quality, and timing of water flowing within and from the outlet. Conversely, water flowing through a watershed works to shape the structure.

We can judge the success of management efforts to attain or maintain TMDL limits by measuring water as it leaves a watershed. Such a black-box evaluation, however, will not help land-managers refine land–use decisions. By quantifying biological and physical structural attributes within a watershed, managers begin building the basis for cause–and–effect evaluations of management efforts. This approach enables managers to recognize and interpret changes within a watershed earlier than with the black-box method. This approach also provides a common language for sharing success and failure information as well as exchanging innovative management ideas. Finally, it allows us to evaluate whether, and to what degree management is effecting changes within the watershed.

An important attribute of a watershed is the form of the stream channel. Stream morphology tells the story of geologic development within a watershed, it reflects the climate, and it responds to changes in land management. Many methods to classify stream morphology have been developed, beginning in 1899 (Davis, 1899). USFS uses the Rosgen (1994) system to inventory streams and rivers within the National Forests. With this method, stream morphology can be quantitatively described in a systematic manner. We used this system to describe portions of the principal headwater tributaries and main stem of the Umatilla River.

Procedure

We chose eight sites along a 56-mi segment of the Umatilla River to classify during October 1997. We judged these sites to be representative of the stream morphology on the main stem of the Umatilla River from the Umatilla National Forest to near the mouth at the Columbia River. Many headwater tributaries of the Umatilla River originate in the national forest and have been classified by USFS personnel. We extended the classification of the river downstream from the North and South Forks. We conducted a Level II river inventory (Rosgen, 1994), which is a morphological description based on channel patterns, entrenchment ratio, width/depth ratio, sinuosity, channel material, and channel slope (Table 1). We also made note of the presence of wood in the channel, the degree of shading by trees or landscape, and the direction of stream flow. Measurements were made using a 120-ft cloth field tape and a clinometer. Photographs were taken using a single lens (28 mm) reflex camera on 20 February 1998.

Table 1. Definition of terms after Rosgen (1994).

Term	Definition
River mile (RM)	The distance upriver from the rivers mouth.
Channel pattern	The number of channels within a valley or flood plain carrying water. The Columbia River is a single thread channel; a multiple thread river is the mouth of the Mississippi River.
Entrenchment ratio	The width of the flood-prone area to the bankfull surface width of the channel.
Width/depth ratio	The dimension and shape factor calculated from the ratio of bankfull channel width to bankfull mean depth.
Sinuosity	The ratio calculated by dividing stream length by valley length.
Channel materials	The composition of stream or riverbed and banks, i.e., sand, gravel, or boulders.
Canopy	The estimated or measured percent of shade provided by overhanging shrubs or trees.
Azimuth	The direction (North, South, etc.) of flow within a stream segment.
Channel slope	The change in elevation over a given distance, i.e., ft/100 ft or m/100 m.
Manning's *n*	A roughness index derived from an empirical formula that relates stream velocity to channel roughness, shape, and slope.
Classification	Categories of stream morphology based on Rosgen (1994).

Results

Two photographs, with views upstream and downstream, describe each site that we classified.

North Fork, Umatilla River

a) Location (RM) 0.5
b) Width
   low flow (ft) 22
   high flow (ft) 77
c) Channel material gravel, cobble, few boulders
d) Sinuosity medium
e) Wood in channel no
f) Canopy (degrees) 50
g) Azimuth (degrees) 280
h) Slope (%) 2.5
i) Manning's *n* 0.04
j) Classification B4

Plate 1a. North Fork, Umatilla River, view upstream, 20 Feb. 1998.

Plate 1b. North Fork, Umatilla River, view downstream, 20 Feb. 1998.

South Fork Umatilla

a) Location (RM) 0.9
b) Width
   low flow (ft) 22
   high flow (ft) 100
k) Channel material gravel, cobble, few boulders
c) Sinuosity medium
d) Wood in channel no
e) Canopy (degrees) 60
f) Azimuth (degrees) 350
g) Slope (%) 2.5
h) Manning's *n* 0.04
i) Classification B4

B4 streams are moderately sensitive to disturbance by increased streamflow and/or sediment increases, have a moderate sediment supply, low streambank erosion potential, and moderate influence by vegetation on width/depth ratio-stability (Rosgen 1994).

Plate 2a. South Fork, Umatilla River, view upstream, 20 Feb. 1998.

Plate 2b. South Fork, Umatilla River, view downstream, 20 Feb. 1998.

Umatilla River at Corporation, OR

a) Location (RM) 83.1
b) Width
   low flow (ft) 32
   high flow (ft) 67
l) Channel material gravel, cobble, and boulders
c) Sinuosity medium
d) Wood in channel yes
e) Canopy (degrees) 90
f) Azimuth (degrees) 332
g) Slope (%) 0.5
h) Manning's *n* 0.035
i) Classification B4c

The 'c' in the B4c classification represents a decrease in stream slope compared to the North or South Forks of the Umatilla. The description given for the North and South Forks also applies to this site.

Plate 3a. Umatilla River at Corporation, OR, view upstream, 20 Feb. 1998.

Plate 3b. Umatilla River at Corporation, OR, view downstream, 20 Feb. 1998.

Umatilla River at Meachum Creek, OR

a) Location (RM) 81
b) Width
   low flow (ft) 40
   high flow (ft) 260
m) Channel material gravel, cobble, and boulders
c) Sinuosity medium
d) Wood in channel yes
e) Canopy (degrees) 120
f) Azimuth (degrees) 270
g) Slope (%) 1.0
h) Manning's *n* 0.035
i) Classification C4

C4 streams have very high sensitivity to disturbance, are subject to high sediment loads, have very high potential for streambank erosion, and are very highly influenced by vegetation on width/depth ratio-stability (Rosgen, 1994).

Plate 4a. Umatilla River at Meachum Creek, OR, view upstream, 20 Feb. 1998.

Plate 4b. Umatilla River at Meachum Creek, OR, view downstream, 20 Feb. 1998.

Umatilla River at Mission Bridge, OR

a)	Location (RM)	61.5
b)	Width	
	low flow (ft)	197
	high flow (ft)	260
c)	Channel material	basalt
d)	Sinuosity	low
e)	Wood in channel	no
f)	Canopy (degrees)	150
g)	Azimuth (degrees)	280
h)	Slope (%)	1.5
i)	Manning's *n*	0.015
j)	Classification	B1c

B1 stream sensitivity to disturbance is very low and subject to very low sediment loads, have very low streambank erosion potential, and are negligibly influenced by vegetation on width/depth ratio-stability (Rosgen, 1994).

Plate 5a. Umatilla River at Mission Bridge, OR view upstream, 20 Feb. 1998.

Plate 5b. Umatilla River at Mission Bridge, OR, view downstream, 20 Feb. 1998.

Umatilla River at USGS Gauge in Pendleton, OR

a)	Location (RM)	55.0
b)	Width	
	low flow (ft)	92
	high flow (ft)	133
c)	Channel material	basalt
d)	Sinuosity	low
e)	Wood in channel	no
f)	Canopy (degrees)	150
g)	Azimuth (degrees)	260
h)	Slope (%)	1.5
i)	Manning's *n*	0.02
j)	Classification	F1

F1 stream sensitivity to disturbance is low and subject to low sediment loads, have moderate streambank erosion potential, and are little influenced by vegetation on width/depth ratio-stability (Rosgen, 1994).

Plate 6a. Umatilla River at USGS gauge, Pendleton, OR, view upstream, 20 Feb. 1998.

Plate 6b. Umatilla River at USGS gauge Pendleton, OR, view downstream, 20 Feb. 1998.

Umatilla River at Yoakum Bridge, OR

a) Location (RM) 37.8
b) Width
   low flow (ft) 108
   high flow (ft) 148
c) Channel material gravel
d) Sinuosity low
e) Wood in channel no
f) Canopy (degrees) 150
g) Azimuth (degrees) 270
h) Slope (%) 1.0
i) Manning's *n* 0.02
j) Classification F4

F4 streams are extremely sensitive to disturbance by increases in streamflow magnitude and timing or sediment increases, have a very high sediment supply, have very high streambank erosion potential, and are moderately influenced by vegetation (Rosgen, 1994).

Plate 7a. Umatilla River at Yoakum Bridge, OR, view upstream, 20 Feb. 1998.

Plate 7b. Umatilla River at Yoakum Bridge, OR, view upstream, 20 Feb. 1998.

Umatilla River at Echo Bridge, OR

a) Location (RM) 27.0
b) Width
   low flow (ft) 172
   high flow (ft) 219
c) Channel material gravel
d) Sinuosity low
n) Wood in channel yes
   (*infrequent, beaver present)
e) Canopy (degrees) 150
f) Azimuth (degrees) 210
g) Slope (%) 1.0
h) Manning's *n* 0.02
i) Classification F4

Plate 8a. Umatilla River at Echo Bridge, OR, view upstream, 20 Feb. 1998.

Plate 8b. Umatilla River at Echo Bridge, OR, view downstream, 20 Feb. 1998.

Summary

Based on the measured characteristics, some generalizations about the channels can be made.

Two sites, the North Fork and Echo, showed signs of multiple channels. Despite the formation of multiple channels, moderate to high flows would be confined within single channels at both of these sites. Thus, both were considered single-channel patterns, along with all other sites examined.

The variability we found reflects the dynamic character of a river system and ability to transport water and erosion products. As channel morphology changes, water and sediment source areas and storage potential also change. With these changes, the potential for morphological change resulting from management decisions is also altered. Based on broad guidelines by Rosgen (1994), the potential for the Umatilla to reoccupy its floodplain is:

North & South Forks	moderate
Umatilla @ Meachum	good
Umatilla @ Mission	excellent
Umatilla @ Pendleton	fair
Umatilla @ Yoakum	poor
Umatilla @ Echo	poor.

The reoccupation of the floodplain, even were the potential is moderate or better, will require changes in management of the uplands, placement of roads, and access to stream channels. Ultimately, landowners and society will decide whether such changes are desirable.

Conclusions

We assigned a Rosgen (1994) morphological description to eight places on the main stem of the Umatilla River. The criteria used to classify each site are based on a consistent and reproducible procedure. This information serves as a foundation to which information that is more specific can be added. The next step is to conduct Level III and IV inventories (Rosgen, 1994). Level III provides more detail about the condition of the stream and requires measurements of riparian vegetation, depositional patterns, meander patterns, aquatic habitat, flow, channel and bank stability, debris, and river size (Rosgen, 1994). Level IV makes the process dynamic, in that the attributes measured in Level III are measured over time.

Classification is the first step in understanding biological or physical systems. To maintain or improve water quality, which is the purpose of TMDL, we must understand how water, and the energy it carries, flows through a watershed. Through the process of classifying and developing an understanding of the river in action, predictions and evaluations of the effects and consequences of management practices within the watershed can be made and plans can be refined as land managers work to improve and maintain water quality.

Literature Cited

Davis, W.M. 1899. The geographical cycle. Geogr. J. 14 481–541.

Northwest Environmental Defense Center, et al. v. U.S. Environmental Protection Agency. 1986. No. 86–1578 (D., Oregon).

Northwest Environmental Defense Center, et al. v. U.S. Environmental Protection Agency. 1994. No. -–----.

Northwest Environmental Advocates, et al. v. Browner et al.U.S. Environmental Protection Agency. 1996. No. C94–1666R (W.D., Washington).

Rosgen, D.L. 1994. A classification of natural rivers. Catena 22(3):169–199.

U.S. Environmental Protection Agency. 1998. Overview of Total Maximum Daily Loads. Located at http://www.epa.gov/OWOW/tmdl/lawsuit1.html